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AFMC ltr, 19 Feb 2002

RCAF EJECTION EXPERIENCE 1952-1961

By

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The data resulting from use of ejection seats in RCAF aircraft during the decade 1952-1961 has been analysed and it was felt that some of the findings would be of general interest. These include circumstances of the event, equipment, and injuries concluding with an emphasis on spinal fractures. Our ejection experience begain in April 1952 when a pilot escaped uninjured from an F86. His experience and that of the next few aircrew who ejected was obtained by personal interview. Since then each aircrew has completed a questionnaire drawn up by the RCAF Institute of Aviation Medicine. The first form was rather sketchy and follow-up was only made when defective equipment or a near miss was reported. To-day a twelve page report form is used and the pilot or navigator fills it out with the assistance of the Flight Surgeon, the flight safety officer and other specialist officers. The Institute then reviews the case for appropriate action or follow-up after which the most frequently used data is coded onto IBM punch cards.

Between 1952-1961 there were 218 ejections of which 165 or 76% were successful (Table 1). The three types of aircraft shown were the only ones fitted with ejection seats prior to 1961[x]. The F86 was flown mainly by our air division in Europe; the CF100, an all-weather two-man-crew interceptor, was flown in Canada and latterly by air division in Europe as well; and the T33 was used primarily as a trainer for basic training and for practice flying. Their individual success rates ranged from 70% for CF100 to 84% for T33.

RCAF EJECTION EXPERIENCE: DECADE 1952-1961
Success and Fatality
by Type of Aircraft

Success	Type of Aircraft						Total	
	F86		CF100		T33			
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Survived	81	76%	46	70%	38	84%	165	76%
Fatal	26	24%	20	30%	7	16%	53	24%
Total	107	100%	66	100%	45	100%	218	100%

[x] Excluded are the CF101 fitted with standard ejection seats and the CF104 fitted with rocket assisted ejection seats.

The trend by years is shown in Figure 1. The reduced rate of success in 1954 and 1957 although consistent for each type, is not statistically significant. Similarly the slight but general improvement is not statistically significant.

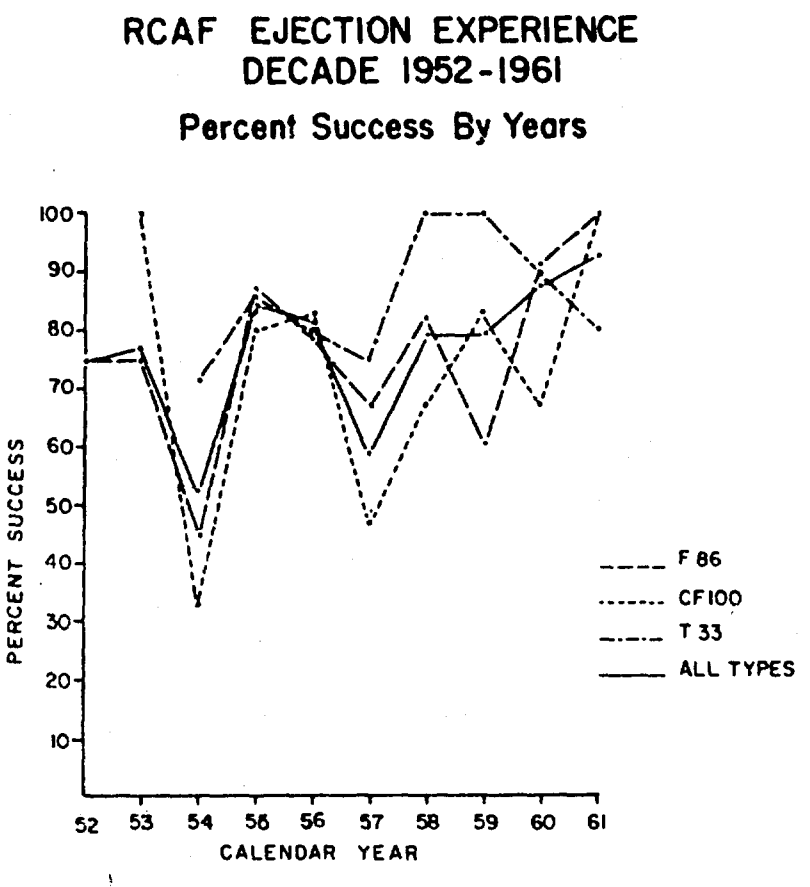

Figure 1

Fifty percent of the 165 successful ejections were made because of loss of control or collision while another 30% were due to fire or engine failure. About one third of all ejections took place within the environs of an airdrome. In many cases they were either local training flights which terminated with the need to eject or unsuccessful attempts by pilots to force land on an airdrome from a distant point at altitude.

The altitude and airspeed conditions of these ejections are shown in Table 2 for all aircraft combined. It is obvious, as one would expect, that high speed success rates are associated with low airspeed above 1,000 ft. Intimately associated with these two variables is attitude. For these aircraft, successful escape has been made from an attitude of level flight as low as 350 ft. above ground. Contrariwise successful escape from a nosetuck vertical dive in CF100 aircraft requires ejection at a minimum indicated altitude

of 21,700 ft. Because attitude is so important in both altitude and high speed cases, success rates for either must be accepted with reservation.

RCAF EJECTION EXPERIENCE: DECADE 1952-1961

Altitude Versus Airspeed

Percent Success

Altitude Above Ground Level (feet)	AIRSPEED									
	LOW (Under 200K)		MODERATE (200-400K)		HIGH (Over 400K)		UNKNOWN		TOTAL	
	Total Ejections	Percent Success	Total Ejections	Percent Success	Total Ejections	Percent Success	Total Ejections	Percent Success	Total Ejections	Percent Success
20,000 and Over	8	87%	17	88%	6	33%	1	100%	32	78%
10,000 - 19,500	15	100%	27	93%	3	0%	2	100%	47	89%
1,000 - 9,500	47	98%	30	90%	6	50%	5	100%	88	92%
450 - 950	12	67%	10	40%	0		4	25%	26	50%
350 - 440	4	100%	1	0%	1	0%	0		6	67%
250 - 340	2	0%	1	0%	0		1	0%	4	0%
150 - 240	2	0%	0		0		0		2	0%
0 - 140	4	0%	1	0%	2	0%	0		7	0%
Unknown							6	0%	6	0%
Totals	94	85%	87	81%	18	28%	19	47%	218	76%

Table 2

With regard to equipment used by the parachutists only two tables are presented. Each aircrew carries an emergency oxygen system designed for in-flight emergencies which includes high altitude escape. It is surprising that only 6 of 15 people (Table 3) who ejected above 20,000 ft. with the system intact, elected to use the supply. This is only 40% utilization. On the other hand some seem to have their drill so well learned that 6 persons operated the system below 10,000 ft. and one of them below a thousand.

The other curious feature was footwear (Table 4) where much discussion has taken place with respect to the requirement for an ankle strap. Altogether there were only two cases in which loss of footwear was reported, neither of which had ankle straps. Both occurred at the opening shock of the parachute canopy. It might be noticed however, that not one of 27 pairs of oxfords was lost. In passing, the case of "other" was a pair of Wellingtons worn by a pilot who wanted to be able to kick off his footwear quickly in the event of descending at sea. As it turned out he ejected over France, lost both boots, touched down in the Rhone River, swam to shore, walked through several stubble fields to reach help and was treated for bruised and lacerated feet.

RCAF EJECTION EXPERIENCE: DECADE 1952-1961

Use of Bailout Oxygen by Altitude at Ejection

Altitude	Bailout Oxygen								Total	
	Used		Not Used		Not Available[x]		Unknown			
	No.	%	No.	%	No.	%	No.	%	No.	%
20,000' and over	6	25	9	37	9	37			24	99
10,000' - 19,500'	8	19	24	57	9	21	1	2	42	99
1,000' - 9,500'	5	6	68	84	7	9	1	1	81	100
450' - 950'	1	8	11	85			1	8	13	101
350' - 440'			4	100					4	100
Unknown	1	100							1	100
Total	21	13	116	70	25	15	3	2	165	100

[x] Of 18 over 10,000 ft., 5 carried no supply, 3 failed to have supply connected, 3 had connections damaged on ejection and 7 lost supply on ejection. All 7 under 10,000 ft. carried no supply.

Table 3

RCAF SUCCESSFUL EJECTIONS: DECADE 1952-1961

Personal Equipment

Type of Footwear Versus Retention on Ejection

Type of Foot Wear	Retained	Lost	Type Worn as Percent of Total Ejections
Warm Weather (5½ inch leather boot with ankle strap)	58		35%
Intermediate (10 inch leather boot with 12 pair lacing eyelets)	58		35%
Mukluks	7	1	5%
Oxfords	27		16%
Other	9	1	6%
Unknown	4		2%
Total	163	2	99%

Table 4

Not only equipment but procedures are important in ejection. Only difficulties in initiating ejection are presented (Table 5), where the similarity between the two operational aircraft is noteworthy. In contrast, twice as many T33 aircrew had difficulty ejecting. This points up the need for aircrew trainees and practice flyers to go through the ejection drill more thoroughly and frequently. Difficulties comprise effecting canopy release, operating the seat firing mechanism, G, windblast and the like.

RCAF SUCCESSFUL EJECTIONS: DECADE 1952-1961

Number of Difficulties in Effecting Ejection

By Type of Aircraft

Difficulties	F86		CF100		T33		Total	
	Cases	Percent of Total	Cases	Percent of Total	Cases	Percent of Total	Cases	Percent of Total
None	58	72%	32	70%	15	39%	105	64%
One	18	22%	10	22%	17	45%	45	27%
Two or More	5	6%	4	9%	6	16%	15	9%
Total	81	100%	46	101%	38	100%	165	100%

Table 5

This then is the background for the injury data which are shown in Table 6, Parts I, II, and III. There, the injuries are shown as rates per 100 ejections for each aircraft type separately and for all types combined. In Part I, Fractures, Sprains and Strains are largely confined to the back. The CF100 has the highest rate for fractures; the T33 for sprains and strains of the back. The next highest rate involves leg and ankle fractures and sprains. The overall rate, however, is only about one quarter of that for the back.

Abrasions and Contusions (Part II) are uniformly high for the leg and ankle whereas lacerations of this site are high only in T33 aircrew. The head is the next most frequent site of lacerations, abrasions and contusions. There are no marked differences between crews of the three types of aircraft.

RCAF EJECTION EXPERIENCE: DECADE 1952-1961

Injuries Reported per 100 Successful Ejections by Type of Aircraft

Part I: Fractures, Sprains and Strains

Injury		F86	CF100	T33	Total
Type	Site	81 Ejections	46 Ejections	38 Ejections	165 Ejections
Fractures					
	Skull-face	1	0	0	1
	Back	19	30	21	22
	Ribs	1	0	0	1
	Leg-Ankle	2	4	8	4
	Foot	0	2	3	1
		23	37	32	29
Sprain and Strain					
	Back	16	13	24	17
	Shoulder	0	7	3	2
	Arm Wrist	1	0	0	1
	Leg-Ankle	11	2	0	6
	Hand	1	0	0	1
	Foot	2	0	0	1
		32	22	26	28

Table 6 Part I

RCAF EJECTION EXPERIENCE: DECADE 1952-1961

Injuries Reported per 100 Successful Ejections by Type of Aircraft

Part II: Lacerations, Abrasions and Contusion

Injury		F86	CF100	T33	Total
Type	Site	81 Ejections	46 Ejections	38 Ejections	165 Ejections
Laceration					
	Skull-face	10	9	3	8
	Arm-Wrist	2	4	3	3
	Leg-Ankle	2	9	24	9
	Hand	0	0	3	1
		15	22	32	21
Abrasion and Contusion					
	Unspecified	6	2	3	4
	Skull-face	10	15	11	12
	Shoulder	6	2	11	6
	Chest	2	2	3	2
	Arm-Wrist	10	7	11	9
	Leg-Ankle	25	39	34	31
	Hand	2	7	3	4
	Foot	1	2	0	1
		63	76	74	69

Table 6 Part II

The remaining injuries are shown in Part III of Table 6. The high rate for burns in T33 aircrew is influenced by one case where both pilots were severely burned about the head and both hands before they were able to eject. The remaining point in the table is the no injury experience. Only about one person in five who successfully ejected, escaped without injury.

To summarize Table 6 and to take fatalities into account: for F86 aircraft there were 107 ejections comprising 26 fatal, 61 with 119 injuries, and 20 with no injuries; for CF100's there were 66 ejections comprising 20 fatal, 37 with 80 injuries, and 9 with no injuries; for T33's there were 45 ejections comprising 7 fatal, 30 with 73 injuries and 8 with no injuries. The differences between aircraft are statistically non-significant.

One further point concerns severity. The injuries in Table 6 comprise all those reported by the medical officers regardless of severity. The argument for exclusion of trivial and minor isn't considered valid for two reasons. Any injury can impair one's chances of survival in a hostile environment and where the hostile environment includes enemy military forces, chances of escape can likewise be impaired. Secondly, this type of injury can be an indicator of poor design and faulty procedures.

One of the analyses of injury carried out with the relationship to drift of the parachutist at touchdown. For this purpose Table 7 includes only those injuries ascribed to the event of landing. Once again the data are insufficient for statistical analysis. However, certain trends are present which might be valid in the long run. There are the association of spinal fracture with zero drift and backward drift, the lack of association between leg fractures and sprains and drift, the high rate of other leg injuries for no drift and the equal-

RCAF EJECTION EXPERIENCE: DECADE 1952-1961

Injuries Reported per 100 Successful Ejections by Type of Aircraft

Part III: Other Injuries

Injury	F86 81 Ejections	CF100 46 Ejections	T33 38 Ejections	Total 165 Ejections
Burns	2	0	16	5
Frostbite	0	4	0	1
Unconsciousness	7	4	0	5
Exposure	2	0	8	3
Other Injuries	1	9	5	4
No Injuries	25	20	21	22

reveals that many of these 165 aircrew are uncertain of parachute control comprising turning to face drift, slipping to avoid obstacles (one person struck a barbed wire fence on a prairie farm) slowing down to reduce drift, and rolling on touchdown to reduce jolt.

RCAF EJECTION EXPERIENCE: DECADE 1952-1961

Injury and Case Rates per 100 Landings according to Drift at Touchdown

Injuries confined to those inflicted upon Touchdown

Direction of Drift at Touchdown	Injury Rate					Case Rate	Number of Ejections
	Spinal Injuries		Leg Injuries		Other Injuries	Persons Injured on Landing	
	Fracture	Sprain	Fracture and Sprain	Other			
None	12	6	12	35	12	47	17
Forward	7	7	12	2	19	32	59
Backward	15	13	8	13	36	38	39
Sideways	6	13	10	6	6	29	31
Unknown	21	11	11	11	53	47	19
Total	11	10	10	10	24	36	165

Table 7

The other important source of injury of course, is the actual ejection from the aircraft between initiation of the event and separation from the ejection seat. These injury rates are presented in Table 8. The position of the body in the seat when the gun fires is germane and, in fact, the low rate of persons injured when seated correctly is statistically highly significant. The salient points of Table 8 are the high rates of back fractures and sprains when the body or head is incorrectly positioned and the high rate of injury to the extremities when they are incorrectly positioned. Having body or head out of position quadruples the chance of spinal injury and extremities being out of position trebles injury to the extremities.

RCAF EJECTION EXPERIENCE: DECADE 1952-1961

INJURY AND CASE RATES PER 100 EJECTIONS ACCORDING TO SEATED POSITION AT INITIATION

Seated Position	Injury Rate				Case Rate Persons Injured on Ejection	Number of Ejections
	Spinal Injury		Other Injuries			
	Fracture	Sprain	Extremities	Other		
Correct	7	4	20	11	23	74
Back/head at least incorrect	31	16	47	37	63	32
Arms/legs only incorrect	8	4	71	17	63	24
Unknown	6	6	17	11	37	35
TOTAL	12	7	32	17	39	165

Table 8

Spinal injuries are of interest on two counts at least. Most importantly they sometimes terminate flying careers. Secondly, it has been stated by some RCAF personnel that one is three or four times as likely to suffer spinal injury ejecting from CF100 aircraft as from others. The CF100 rate of spinal fractures (Table 9) on ejection (26) is statistically significantly high at a ratio of three or four to one to other aircraft. Curiously, however, the ratio of the rates is reversed in the landing phase. Analysis shows the CF100 total spinal fracture rate (30) is not statistically significantly high. There is reason to suppose that an element of bias exists here. It is known to aircrew and medical officers alike that the CF100 ejection gun is an 80 ft/sec gun compared with 60 ft/sec in the other two aircraft. Secondly, the CF100 seat has a 12^{o} angle between the line of the seat back and the line of the gun whereas the other two have these two lines parallel. These facts probably have influenced the field to attribute nearly all spinal injuries in CF100 ejections to the forces of ejection. For other aircraft the majority are attributed to the landing phase. It may well be that the forces of ejection are under-estimated for the 60 fps gun in F86 and T33 aircraft.

RCAF EJECTION EXPERIENCE: DECADE 1952-1961

SPECIAL INJURIES ACCORDING TO PHASE OF EJECTION

INJURY RATES PER 100 EJECTIONS BY AIRCRAFT

Phase of Ejection	Aircraft	Spinal Injuries		Number of Ejections
		Fracture	Sprain	
Initiation to Seat Separation	CF100	26	13	46
	F86	7	6	81
	T33	3	0	38
Landing	CF100	4	0	46
	F86	11	10	81
	T33	18	24	38
TOTAL	CF100	30	13	46
	F86	19	16	81
	T33	21	24	38

Table 9

Further on the general question of spinal injuries, the two seat guns are compared by the distributions of fractured vertebrae. Figure 2 shows the distribution of 30 vertebrae fractured in 13 known cases (one unknown)arising from CF100 ejections. This distribution ranges from T5 to L4 and has a mode

of L12. Welch's USN distribution for the same 80 fps gun is centered about T10 but covers the same range. On the basis of his data our expected number of fractured vertebrae would have been 24.

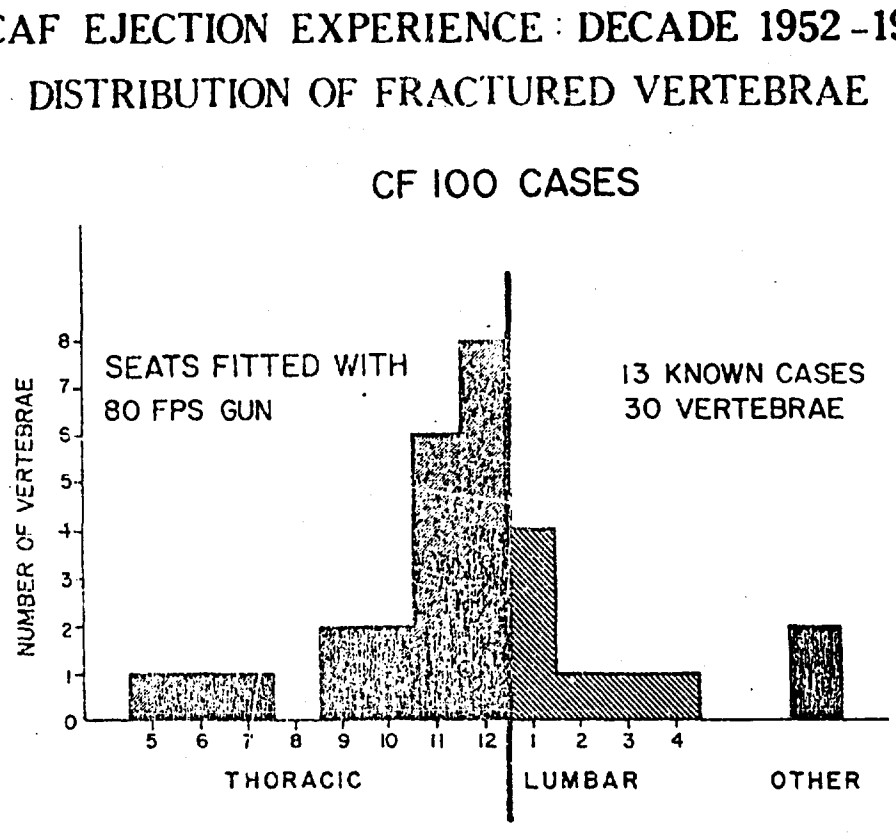

Figure 2

The same data is shown in Figure 3 for 60 fps guns (F86 and T33 aircraft combined). Data were reported on only 17 of 23 persons. The same type of distribution is again evidenced with mode at L1 instead of T12. However, this distribution is markedly different from Welch's corresponding USN data. The USN distribution is virtually rectangular from C2 to L5. Furthermore, projecting the USN data to our 119 ejections we would have expected only 7 fractured vertebrae.

RCAF EJECTION EXPERIENCE : DECADE 1952 - 1961
DISTRIBUTION OF FRACTURED VERTEBRAE
F86 & T33 CASES

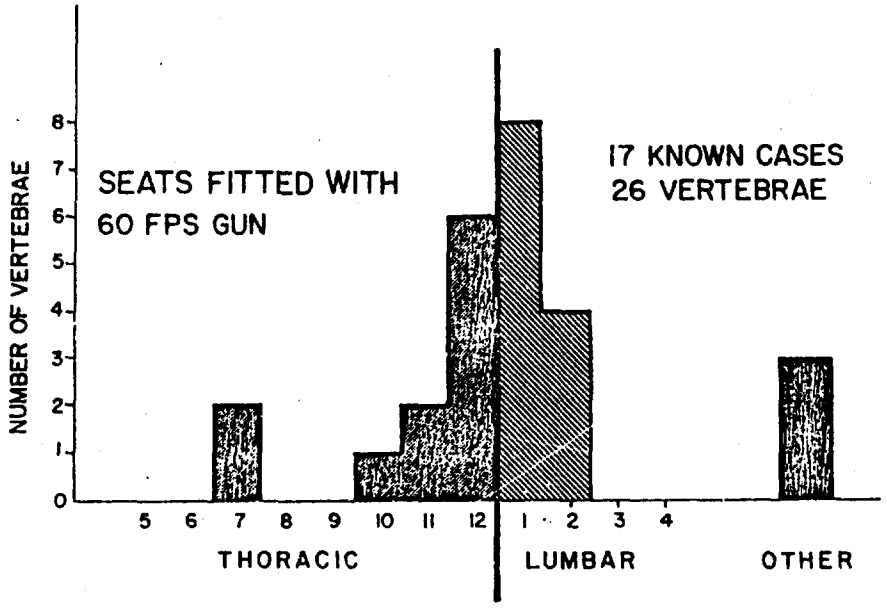

Figure 3

For RCAF data, the type of ejection seat apparently does not influence the distribution of fractured vertebrae. In both instances the distributions are clustered in the area of spinal flexion. Had the circumstances of RCAF ejections been the same as for the USN then we would have expected only a 17 per cent (30-24)/30) reduction in the number of fractured vertebrae in CF100 ejections. But for F86 and T33 aircraft the reduction would have been 73 per cent (26-7)/26) and there would have been no clustering in the area of spinal flexion.

Very likely most, if not all, of the 17 per cent difference can be attributed to better use of seat harness by navy flyers exposed to catapult takeoffs and especially arrestor landings. However, this factor can at most be only a partial explanation of the 73 per cent discrepancy for RCAF F86 and T33 aircraft. Other factors must be examined such as the design and

attachment of seat harness and possibly the man-seat coupling system.

Notwithstanding this emphasis on spinal injuries, it is clear that the rates for all types of injuries are higher than they need be. In the RCAF 75 per cent to 80 per cent of all aircrew successfully ejecting from aircraft suffer injuries. Aside from modification of equipment, it would appear that aircrew could benefit by more instruction in all phases of ejection from cockpit drill to control of parachute.

SUMMARY

The RCAF has had a 76% success with standard ejection systems. The success rose to 94% when the equipment was used above 1,000 ft. and at airspeeds under 400 K.

Practice flying aircrew and trainees have a high frequency of difficulties affecting ejection.

Injury rates are significantly increased when the body is not correctly positioned upon firing the ejection seat.

Aircrew have high injury rates on landing and are frequently uncertain how to control their descent to a better touchdown.

Spinal injuries appear to be high for RCAF aircrew probably due to failure to tighten their seat harness. In addition some factor such as type and attachment of harness or the man-seat coupling system appears to be operative.

REFERENCE

1. Welch, E. S.: Injuries Associated with the Use of Ejection Seats in the U.S. Navy; 1 September 1958 to 29 August 1961. Paper presented to the Fourth Joint Committee on Aviation Pathology meeting RCAF Station Downsview, October 1961.

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS AIR FORCE MATERIEL COMMAND
WRIGHT-PATTERSON AIR FORCE BASE OHIO

FEB 19 2002

MEMORANDUM FOR DTIC/OCQ (ZENA ROGERS)
8725 JOHN J. KINGMAN ROAD, SUITE 0944
FORT BELVOIR VA 22060-6218

FROM: AFMC CSO/SCOC
4225 Logistics Avenue, Room S132
Wright-Patterson AFB OH 45433-5714

SUBJECT: Technical Reports Cleared for Public Release

References: (a) HQ AFMC/PAX Memo, 26 Nov 01, Security and Policy Review, AFMC 01-242 (Atch 1)

(b) HQ AFMC/PAX Memo, 19 Dec 01, Security and Policy Review, AFMC 01-275 (Atch 2)

(c) HQ AFMC/PAX Memo, 17 Jan 02, Security and Policy Review, AFMC 02-005 (Atch 3)

1. Technical reports submitted in the attached references listed above are cleared for public release in accordance with AFI 35-101, 26 Jul 01, *Public Affairs Policies and Procedures*, Chapter 15 (Cases AFMC 01-242, AFMC 01-275, & AFMC 02-005).

2. Please direct further questions to Lezora U. Nobles, AFMC CSO/SCOC, DSN 787-8583.

Lezora U. Nobles

LEZORA U. NOBLES
AFMC STINFO Assistant
Directorate of Communications and Information

Attachments:
1. HQ AFMC/PAX Memo, 26 Nov 01
2. HQ AFMC/PAX Memo, 19 Dec 01
3. HQ AFMC/PAX Memo, 17 Jan 02

cc:
HQ AFMC/HO (Dr. William Elliott)

DEPARTMENT OF THE AIR FORCE

HEADQUARTERS AIR FORCE MATERIEL COMMAND
WRIGHT-PATTERSON AIR FORCE BASE OHIO

NOV 2 6 2001

MEMORANDUM FOR HQ AFMC/HO

FROM: HQ AFMC/PAX

SUBJECT: Security and Policy Review, AFMC 01-242

1. The following material has been reviewed for security and policy IAW AFI 35-101, Chapter 15. It is cleared for public release:

   a. "Investigation of A-4 Sight in F-86E Airplane, 18 July 1952, DTIC No. AD-473 192

   b. Operational Suitability Test of Open Gun Ports for F-86 Aircraft, 31 August 1949, DTIC No. AD-B971 411

   c. Letter Report on Relative Aerial Combat of the F-84E Versus the F086A Capability, 30 January 1951, DTIC No. AD-B971 840.

2. Two reports require clearance from other organizations. Hypoxia and Undetermined Jet Accidents," will be reviewed by 311th Human Systems Wing, and "RCAF Ejection Experience," will be forward to Air Staff for coordination with RCAF.

3. If you have any questions, please call me at 77828. Thanks.

JAMES A. MORROW
Security and Policy Review
Office of Public Affairs

Attachment:
Your Ltr 26 November 2001

26 November 2001

MEMORANDUM FOR: HQ AFMC/PAX
Attn: Jim Morrow

FROM: HQ AFMC/HO

SUBJECT: Releasability Reviews

1. Please conduct public releasability reviews for the following attached Defense Technical Information Center (DTIC) reports:

   a. *Investigation of A-4 Sight in F-86E Airplane*, 18 July 1952; DTIC No. AD- 473 192.

   b. *Operational Suitability Test of Open Gun Ports for F-86 Aircraft*, 31 August 1949; DTIC No. AD-B971 411.

Cleared AFMC 01-259

   c. *Hypoxia and Undetermined Jet Accidents*, 19 October 1956; DTIC No. AD-115 661.

   d. *Letter Report On Relative Aerial Combat Of The F-84E Versus The F-86A Capability*, 30 January 1951; DTIC No. AD-B971 840.

Cleared AFMC 01-260

   e. *RCAF Ejection Experience, 1952-1961*, 1965; DTIC No. AD-465 171.

2. These attachments have been requested by Dr. Kenneth P. Werrell, a private researcher.

3. The AFMC/HO point of contact for these reviews is Dr. William Elliott, who may be reached at extension 77476.

JOHN D. WEBER
Command Historian

5 Attachments:
a. DTIC No. AD- 473 192
b. DTIC No. AD-B971 411
c. DTIC No. AD- 115 661
d. DTIC No. AD-B971 840
e. DTIC No. AD- 465 171